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U.S. Department of Transportation
Federal Aviation Administration
Specification

CABLE, FIBER OPTIC, MULTIMODE, MULTIFIBER

1. SCOPE AND CLASSIFICATION

1.1 Scope.- This specification contains requirements for a multiple-fiber, dual-window, graded-index, optical waveguide, control or communications cable intended for data and communications use at airports.

1.2 Classification.- Six types of cables are covered by this specification:

Type A Six-fiber non-armored totally dielectric cable having a dielectric strength member for duct installation in areas subject to frequent electrical storm activity.

Type B Six-fiber cable having a dielectric strength member and corrugated bimetal (copper over steel) armor, for installation by direct earth burial where rodent protection is required.

Type C Two-fiber (duplex) loose tube, non-gel-filled cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke producing material. It shall be in accordance with Article 770, "Optical Fiber Cable" of National Fire Protection Association Publication 70 (National Electrical Code). See 6.2 for further information.

Type D Same as Type A, but with an intermediate polyvinylidene fluoride sheath to provide protection from hydrocarbon fuels.

Type E Same as Type B, but with an intermediate polyvinylidene fluoride sheath to provide protection from hydrocarbon fuels.

Type F Two-fiber (duplex) tight buffer, cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke producing material. It shall be in accordance with Article 770, "Optical Fiber Cable" of National Fire Protection Association Publication 70 (National Electrical Code). See 6.3 for further information.

1.3 Environmental conditions.- Types A, B, D and E cable shall meet the following environmental requirements:

1.3.1 Temperature

1.3.1.1 Operating.- -40° C to +60° C (-40° F to +140° F).

1.3.1.2 Storage.- -40° C to +65° C (-40° F to +149° F).

1.3.1.3 Installation.- 0° C to 40° C (32° F to 104° F).

1.3.2 Immersion

1.3.2.1 Water.- The cable shall not be damaged by immersion in water; i.e., ground or duct water, but is not marine cable.

1.3.2.2 Hydrocarbon fuels.- The performance of cable Types D and E shall not be affected by immersion in hydrocarbon fuels.

1.3.3 Installation environment

1.3.3.1 Ducts.- Applicable.

1.3.3.2 Direct Earth Burial.- Applicable.

1.3.3.3 Aerial.- Applicable. Will require external messenger wire.

1.3.3.4 Marine.- Not applicable.

1.4 Definition of terms

1.4.1 Multimode.- The term "multimode," as used herein, shall denote a fiber designed to transmit light at more than one electromagnetic mode.

1.4.2 Dual-window.- The term "dual-window," as used herein, shall denote the capability of the fiber to transmit light energy with minimum loss at two separate wavelengths: 850 nanometers and 1300 nanometers.

1.4.3 Graded-index.- The term "graded-index," as used herein, shall denote a fiber whose core is composed of a series of concentric rings of silica having successively lower refractive indices. This allows the light farther from the central axis to travel faster so that all modes of light propagation tend to arrive at any point concurrently, thus reducing dispersion.

1.4.4 Numerical aperture.- The term "numerical aperture," as used herein, is a dimensionless number denoting the sine of the acceptance cone half-angle. It is a measure of the fiber's ability to accept lightwaves from various angles.

1.4.5 Bandwidth.- The term bandwidth, as used herein, refers to the 3 dB intermodal optical bandwidth.

1.4.6 Zip-cord.- A duplex optical communications cable having a single fiber in each of two parallel buffer tubes. Each buffer tube is of circular (annular) cross section and has its own braided or helically wound strength member of aramid yarn, over which is extruded a plastic jacket of circular (annular) cross section. The two tubes are connected by a narrow bridge of material which conjoins the jackets.

1.4.7 Units.- The following measurement units are used in this specification:

nanometer (nm) = 10^{-9} meter = one billionth of a meter

micron (um) = 10^{-6} meter = one millionth of a meter

millimeter (mm) = 10^{-3} meter = one thousandth of a meter

kilometer (km) = 10^{3} meters = one thousand meters

megahertz (MHz) = 10^{6} hertz = one million hertz

decibel (dB) = ten times the ratio of optical power levels expressed as a logarithm to the base 10

Newton (N) = a metric unit of force equivalent to 0.225 pound-force

2. APPLICABLE DOCUMENTS

2.1 General.- The following documents form a part of this specification to the extent specified herein. In the event of a conflict between this specification and the following documents, this specification shall have precedence.

2.2 American Society for Testing and Materials (ASTM) specifications

D1248 Polyethylene Plastic Molding and Extrusion Materials

2.3 American National Standards Institute/Electronic Industries Association (ANSI/EIA) standards

EIA-455 Fiber Optic Test Procedures:

FOTP 25 Impact Testing of Fiber Optic Cables and Cable Assemblies, 1980

FOTP 30 Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity, 1982

FOTP 31A Fiber Tensile Proof Test Method, 1987

FOTP 33 Fiber Optic Cable Tensile Loading and Bending Test, 1982

FOTP 37 Fiber Optic Cable Bend Test Low and High Temperature, 1983

FOTP 41 Compressive Loading Resistance of Fiber Optic Cables, 1985

FOTP 45 Microscopic Method for Measuring Fiber Geometry of Optical Waveguide Fibers, 1984

FOTP 47 Output Far-Field Radiation Pattern Measurement, 1983

FOTP 52 Method for Measuring Temperature Dependence of Attenuation, 1983

FOTP 53 Attenuation by Substitution Method Measurement - for Multimode Graded-Index Optical Fibers or Fiber Assemblies Used in Long Length Communication Systems, 1985

FOTP 81 Compound Flow (Drip) Test for Filled Fiber Optic Cable, 1985

2.4 Insulated Cable Engineers Association/National Electrical Manufacturers Association (ICEA/NEMA) Publications

ICEA Publication No. S-61-402 (Third Edition), Revision No. 11, December 1984; Thermoplastic-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

2.5 National Fire Protection Association (NFPA) codes

NFPA 70-1984 National Electrical Code (Revision, 1984)

2.6 Document sources.- Copies of this specification may be obtained from the contracting officer in the FAA office issuing the IFB or RFP. Requests should fully identify this specification by number, title, date of issue, etc., and should identify the IFB, RFP or contract involved, or other use to be made of the specification.

ASTM specifications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ANSI/EIA standards may be obtained from the Electronic Industries Association, 2001 Eye Street NW, Washington, D.C. 20006.

ICEA specifications may be obtained from the Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, MA 02664.

NFPA specifications may be obtained from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

3. REQUIREMENTS

3.1 Introduction.- The fiber optic cable described in this specification will be a fundamental part of a communications system for use at airports. The requirements presented herein are intended to result in a highly reliable cable which can be procured by the FAA for use in these applications.

3.2 Materials.- Materials shall be as specified herein. Materials which have not been defined by this specification shall be entirely suitable for the application. The manufacturer shall certify that all synthetic substances were produced from virgin compounds.

3.3 Workmanship.- The cable shall be designed and manufactured in accordance with best commercial practices. The cable shall be free of any imperfections that may affect its serviceability.

3.4 Fiber and cable

3.4.1 Fiber.- The fiber shall be a multimode dual-window fiber of all silica-based composition, with a core having a fully-graded refractive index profile (nominal profile parameter of 2).

3.4.1.1 Core diameter.- The core diameter shall be 50 ± 3 um.

3.4.1.2 Cladding diameter.- The cladding diameter shall be 125 ± 3 um.

3.4.1.3 Protective coating diameter.- The outside diameter of the protective coating shall be 250 ± 25 um. The protective coating shall be easily stripped by common chemical means.

3.4.1.4 Temperature dependence of attenuation.- The temperature dependence of attenuation, as measured by FOTP 52, shall not exceed 0.2 dB/km over the temperature range -40° C to +60° C (-40° F to +140° F).

3.4.1.5 Numerical aperture.- The numerical aperture of the fiber shall be either 0.20 ± 0.015 or 0.22 ± 0.020, as determined in accordance with FOTP 47, method A, B or C. The numerical aperture of all fibers within the same cable shall be identical; i.e. either all 0.20 ± 0.015 or all 0.22 ± 0.020, but not a mixture of both.

3.4.1.6 Attenuation.- The attenuation of the cabled fiber, as measured by FOTP 53 - Procedure C, shall not exceed 3.5 dB/km at 850 nm nor 1.0 dB/km at 1300 nm at 20° C (68° F).

3.4.1.7 Optical bandwidth.- The 3 dB optical bandwidth of the cabled fiber, as measured by a frequency-domain technique (FOTP 30) shall be at least 400 MHz-km at 850 nm, and at least 800 MHz-km at 1300 nm.

3.4.1.8 Core-cladding offset.- The core-cladding offset, as determined by the method described in FOTP 45, shall not exceed 3 um.

3.4.1.9 Ovality.- The ovality of neither the core nor the cladding shall exceed 0.06, as defined in FOTP 45.

3.4.1.10 Tensile Strength.- The tensile strength of the fiber as measured by FOTP 31A, shall not be less than 100 KPSI.

3.4.2 Cable performance.

3.4.2.1 Cable storage.- There shall be no deterioration of the cable, fiber integrity, or optical capability due to outdoor storage of the cable on the shipping reel.

3.4.2.2 Installation bending radius and pulling force.- The cable shall be designed to perform satisfactorily under the following installation conditions:

a) Bending radius as little as 20 times cable diameter

b) Pulling force as much as 450 pounds (2000 Newtons)

3.4.2.3 Long-term bending radius and post installation conditions.- The cable shall be designed to perform satisfactorily under the following post-installation conditions:

a) Bending radius as little as 15 times cable diameter

b) Residual force as much as 50 pounds

3.4.2.4 Crush resistance.- The crush force the total cable shall withstand without degrading the cable performance is 600 N/cm for cable types A and D, 400 N/cm for type C and F, and 800 N/cm for types B and E.

3.4.2.5 Impact resistance.- The total cable shall withstand, without degrading, twenty impacts with a 1.27 cm. radius hammer. The impact force shall be 3 N·m for cables types A and D, 1.5 N·m for type C and F, and 5 N·m for types B and E.

3.4.3 Cable construction

3.4.3.1 Unspliced length.- The unspliced cable length on each delivered reel shall be 2.2 km in accordance with 5.1 unless otherwise specified.

3.4.3.2 Central strength member.- The central strength member of Types A, B, D and E cable shall be totally dielectric and fully compatible with other cable components.

3.4.3.3 Fiber Protection.- For Types A, B, D and E cables, buffer tubes containing a gel filling compound shall be used to provide a moisture-free environment for the fiber. The buffer tubes containing the fiber shall be

helically wrapped about the central strength member at a lay length that will ensure a stress-free environment for the fiber over the specified range of environmental conditions, including storage and installation stresses (see 1.3, 3.4.2). Type C cables shall be non-gel-filled, loose-buffer tube, zip-cord design. Type F cables shall be tight buffer tube, zip-cord design.

3.4.3.3.1 Buffer tubes.- The buffer tube material shall be fully compatible with other materials used in the cable. The tube outer diameter shall be no greater than 2.5 mm and no less than 1.0 mm. The buffer tubes shall be made of a material that will resist permanent deformation. The loose buffer tubes shall break easily and cleanly when circumscribed by a sharp knife or razor blade and bent. The tight buffer tubes shall be capable of being easily stripped using a .014 in. wire stripper. The tubes shall be suitably color-coded according to Appendix K of S-61-402. The buffer tubes for Type C and F cables shall be produced from a non-halogenated, low smoke-producing material.

3.4.3.3.2 Gel filling compound.- The gel filling compound in Types A, B, D and E cables is to prevent the intrusion of water and/or water vapor at temperatures up to 65° C (149° F). The gel filling compound shall be neither toxic nor a dermal irritant. If colored, the coloring shall not interfere with the identification of the color-coded buffer tubes. The gel shall be fully compatible with the other materials used in the cable. It shall be easily removable with a clean, dry cloth. Any residual gel shall be easily removable by a commonly used solvent.

3.4.3.4 Tape wrap.- The buffer tubes shall be held in place by a helically wrapped tape or binder compatible with the buffer tube and gel flooding compound materials.

3.4.3.5 Inner sheath (Types A, B, D and E).- The inner sheath shall be continuous extruded polyethylene having a thickness of 0.8 mm $\pm$ 5% with no voids or inclusions. The sheath material shall have aging characteristics consistent with a 40-year life expectancy of the cable.

3.4.3.6 Intermediate Sheath (Types D and E only).- The intermediate sheath shall be continuous extruded polyvinylidene fluoride copolymer having a thickness of 0.50 mm $\pm$ 5% with no voids or inclusions. A different fluoropolymer substance or elastomer may be proposed. However, it shall be subject to the FAA Contracting Officer's approval.

3.4.3.7 Armor (Types B and E).- A corrugated bimetal (copper over steel) armor, coated with a heat-sealable substance shall be applied over the sheath specified in 3.4.3.5 (Type B) and 3.4.3.6 (Type E). The characteristics of the heat-sealable substance, particularly those which change as a function of

temperature and aging, shall be fully compatible with the other materials used in the cable. The thickness of the bimetal shall be greater than or equal to 0.15 mm; the nominal thickness of the coating shall be 0.05 mm. The armor shall be easily removable by the rip cord specified in 3.4.3.10.

3.4.3.8 Exterior sheath

3.4.3.8.1 Types A, B, D and E.- The exterior sheath shall be continuous extruded high-density polyethylene conforming to ASTM D1248 (IC5-J3, IIC5-J3, or IIIC5-J5), having a thickness of 1.25 mm ± 5% with no voids or inclusions. The outer diameter of the cable shall be uniform within 2.5 percent. It shall contain carbon black and antioxidant substances to protect the cable from ultraviolet light and shall have aging characteristics consistent with a 40 year cable life expectancy. It shall be applied over the inner sheath (Type A), over the intermediate sheath (Type D), or over the corrugated bimetal armor (Type B and E).

3.4.3.8.2 Type C and F.- The exterior sheath shall be a flame-retardant, non-halogenated, low smoke-producing material suitable for interior installation in cable trays or electrical raceways per NFPA 70, Article #770.

3.4.3.9 Interstitial protection (Types A, B, D and E).- A two part silicone flooding compound which can be easily removed when cured shall be used to prevent the intrusion of water into the interstices of the cable within the boundary defined by the exterior sheath.

3.4.3.10 Rip cords (Types A, B, D and E).- At least two rip cords shall be incorporated; one for stripping the armor (Types B and E) and outer jacket (all types), and one for stripping the intermediate sheath (Types D and E) and inner sheath (all types).

3.4.3.11 Cable identification.- The exterior sheath of all cables shall be permanently marked at intervals not exceeding two meters with the following information: manufacturer's name or trademark; year of manufacture; type of cable; numerical aperture; attenuation and bandwidth at both wavelengths; and contract number. For example: "SMITH CABLE CO. 1987 6-fiber Type B ARM 0.20NA-850/3.5/400--1300/1.0/800 DOT-FA-85-AC-1000.

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality control provisions.- The contractor shall provide and maintain a quality control program. All tests shall be performed by the Contractor and shall be witnessed by the Government. If Government witnessing is waived,

the contractor shall furnish two copies of certified test data. The cable will not be accepted by the Government until the test data, certified by a properly authorized official of the Contractor to be true, correct, complete and satisfying the specification requirements, has been submitted to and approved by the Government. All tests shall be performed at the time of manufacture. Any reel of cable or specimen offered for inspection but failing to meet the requirements of the test may not be reoffered for a retest without approval of the Contracting Officer.

4.2 Test samples.- Testing shall be performed on the basis of sampling. The sampling is defined in 4.2.1 and 4.2.2.

4.2.1 Inspector's Samples.- To provide specimens for various tests, one 25-meter length of cable shall be cut from the end of reels to be selected randomly, with a maximum sampling of one sample per each 11 km. A minimum sample for orders less than 11 km is one sample. For example, an order for 110 km of fiber optic cable would be packaged on 50 2.2-km reels. A sample shall be taken at random from each lot of five reels, for a total of ten samples. Each sample will be identified by reel number, contract/order number, and specification number. The reels shall be numbered sequentially for this purpose in the order of manufacture.

4.2.2 Referee samples.- When so stated in the IFB or RFP, samples of the completed cable not less than five meters long shall be supplied to an independent testing laboratory selected by the Contracting Officer. One sample shall be taken from one of the first five reels in an order, and an additional sample shall be taken from one of each additional ten reels or less of the order. In the example of 4.2.1, if referee samples were required, one would be taken from the first five reels, one each from the next four groups of ten reels, and one from the last five reels, for a total of six samples. Samples and reels shall be identified in accordance with 4.2.1. Shipment of samples, if required, will be done at Government expense. Packing samples and delivery to a common carrier will be at the Contractor's expense.

4.3 Cable testing

4.3.1 Fiber.- All fibers in the finished cable shall have been tested prior to cabling in accordance with the definitions and procedures specified in the EIA-455 Fiber Optic Test Procedures (FOTPs) to validate the specifications of Paragraph 3.4.1.7. Certified test results including test procedures from the fiber manufacturer shall be furnished demonstrating compliance for the following properties:

(a) Core Diameter (see 3.4.1.1)

(b) Cladding Diameter (see 3.4.1.2)

(c) Protective Coating Diameter (see 3.4.1.3)

(d) Numerical Aperture (see 3.4.1.5)

(e) Core-Cladding Offset (see 3.4.1.8)

(f) Ovality (see 3.4.1.9)

(g) Proof Test (see 3.4.1.10)

4.3.2 Cable assembly tests.- The following tests shall be performed on specimens of completed cable. The Contracting Officer shall be notified in the event of failure to pass any test.

4.3.2.1 Optical attenuation.- The optical attenuation and bandwidth of the cable shall be validated in accordance with the requirements of 3.4.1.6 on all fibers of every reel of finished cable.

4.3.2.2 Temperature dependence of attenuation.- The temperature dependence of attenuation shall be measured per FOTP 52 (for 48 hours or when it is ensured that the cable has uniformly reached the test temperature) on all fibers of one reel of cable selected at random. Measurements shall be made at -40° C and +60° C, $\pm$ 2° C.

4.3.2.3 Exterior sheath integrity.- The exterior sheath shall be 100% inspected by the manufacturer to ensure that the sheath is free from voids. For armored cable (Types B and E) this shall be done by a spark test at a voltage of 4,000 VDC. Types A, C, D and F cable shall be inspected in accordance with the manufacturer's normal Quality Control Procedures.

4.3.2.4 Cable flexing.- The specimen(s) taken from the sample(s) specified in 4.2.1 shall be prepared in accordance with FOTP 37, except that a mandrel having a diameter up to 20 times the cable diameter shall be permitted. Test condition D (0° C and 40° C) of Table I of FOTP 37 shall suffice, as shall Test Level 2 (10 mandrel turns) of Table III. The test mass shall be in accordance with Table II.

4.3.2.5 Gel filling compound flow test.- Test specimens taken at random from the samples specified in 4.2.1 shall be subjected to a gel filling compound flow test in accordance with FOTP 81, Method B, at a temperature of 60° C $\pm$ 2° C (140° F). There shall be no evidence of gel compound flowing or dripping from any buffer tube or other cable component.

4.3.2.6 Cable pulling capacity test.- This test shall be performed in accordance with FOTP 33. This test shall be a type acceptance test on a production run basis.

4.3.2.7 Sheath material properties certification.- The manufacturer shall certify, based on standard Quality Control tests, that the extrusion process used for application of the sheathing compound complies with the recommendations of the compound supplier.

4.3.2.8 Crush resistance test.- Test specimens taken at random from the samples specified in 4.2.1 shall be subjected to the crush force specified in 3.4.2.4. The optical attenuation shall not change from before the test to after the test in the tested sample.

4.3.2.9 Impact resistance test.- Test specimens taken at random from the samples specified in 4.2.1 shall be subjected to the impact force specified in 3.4.2.5. The optical attenuation shall not change from before the test to after the test in the tested sample.

5. PREPARATION FOR DELIVERY

5.1 Cable length per reel.- Cable shall be delivered on nonreturnable reels in one continuous length of 2.2 km, -5%, +10% per reel, unless otherwise specified, in accordance with the following table.

National Stock Number	Type	Description	Maximum Length per Reel
6015-01-243-1697-1	A	6-fiber exterior, non-armored	2.2 km
6015-01-243-1698-1	B	6-fiber exterior, armored	2.2 km
6015-01-243-1699-1	C	2-fiber interior, loose tube	2.2 km
6015-01-243-1700-1	D	6-fiber exterior, non-armored, intermediate sheath	2.2 km
6015-01-243-1701-1	E	6-fiber exterior, armored, intermediate sheath	2.2 km
6015-01-274-5849-1	F	2-fiber interior, tight buffer	2.2 km

5.2 Reel construction.- Reels used shall be built to protect the cable fully from shipping hazards, and shall provide long-term outdoor storage protection from wind, sand, rain, snow, sunlight (i.e., ultraviolet radiation), etc. Each end of the cable shall be sealed to prevent the entry of moisture and contamination. At least five meters of cable from the inside of the reel shall be free and accessible for testing purposes.

5.3 Reel marking.- The contractor's name, contract number under which the cable was purchased, NSN, actual length and type of cable, cable installation temperature range (prominently marked), and the name and address of the consignee shall be applied plainly on both outer reel flanges with permanent ink or paint.

6. NOTES

6.1 Note on information items.- The contents of the subparagraphs below are only for the information of the initiator of the procurement request and the Contracting Officer, intended to assist them in formulating a contract. They are not contract requirements, nor are they binding on either the Government or the contractor except to the extent to which they may be specified elsewhere in the contract as such. The contractor shall not rely on the information in these subparagraphs.

6.2 Type C cable.- Type C is intended to be any commercially available dual-window, two-fiber (duplex), loose-tube,, non-gel-filled cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke-producing material suitable for use in accordance with paragraph #770, "Fiber Optic Cables" of National Fire Protection Association publication 70 (National Electric Code). The test requirements of this specification are not applicable to this type.

6.3 Type F cable.- Type F is intended to be any commercially available dual-window, two-fiber (duplex), tight buffer, cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke-producing material suitable for use in accordance with paragraph #770, "Fiber Optic Cables" of National Fire Protection Association publication 70. The test requirements of this specification are not applicable to this Type.